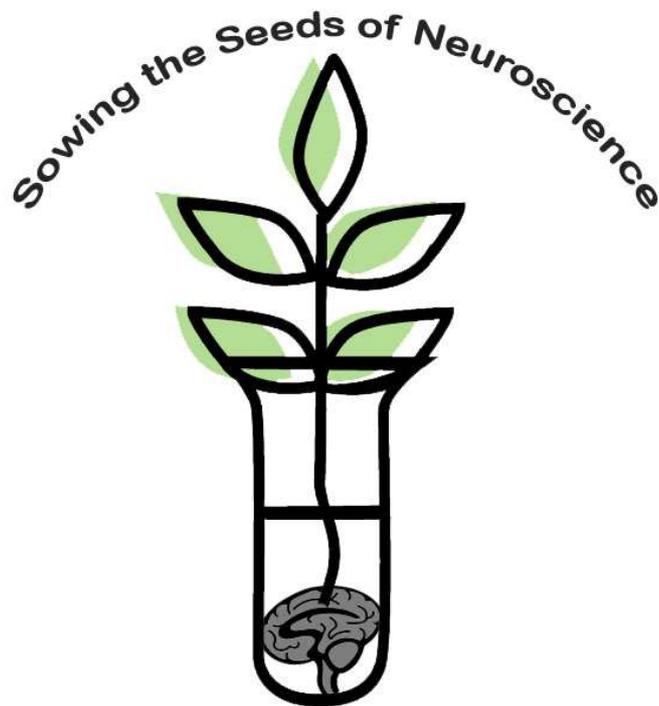


Sowing the Seeds of Neuroscience

Botanical Superheroes: Investigating the Antibacterial Properties of Plant Extracts



Botanical Superheroes: Investigating the Antibacterial Properties of Plant Extracts

Activity Time: One 50 minute class period followed by 20-30 minutes the following day. During the 4-10 days of incubation time, students may need an additional 10-20 minutes of several class periods to make observations of bacterial growth. A third 50 minute class period is needed to wrap-up the activity and complete assessment tasks.

Lesson Summary:

In this lesson, students learn that bacteria can cause illness, including neurological diseases such as meningitis. In the lab portion, they examine whether some plant extracts are effective at slowing down the growth of bacteria. Students will expose bacteria to penicillin, water, and several different plant extracts (including garlic juice and the essential oils of tea tree and clove) to determine whether plant extracts inhibit bacterial growth.



STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding

- **Antibacterial Properties of Plants:** Garlic and some other plant extracts inhibit bacterial growth. Plants with antibacterial properties may be able to reduce the incidence of bacteria-borne illnesses, including some neurological diseases.

Essential Question

- Can plant extracts prevent the growth of bacteria?

Neuroscience Core Concepts

- Brain research promotes health and leads to understandings and therapies.
- The plant world is filled with species that contain chemicals with medical properties, including neuroactive properties.
- Traditional healers around the world use plants to treat illness, including mental illness.
- There are many people with mental and neurological disorders in our society.

Learning Objectives

Students will know...

- There are many people with mental and neurological disorders in our society, some of which, like meningitis, are caused by bacteria.
- Some plant extracts may prevent the growth of bacteria—which may reduce the incidence of bacteria-borne illness.
- Plant extracts may contain chemicals which can treat mental and neurological disorders.

Students will be able to...

- Demonstrate lab safety procedures.
- Follow the procedures to successfully inoculate a plate with *M. luteus* bacteria.
- Set up an experiment that compares bacterial growth under several conditions.
- Name at least two plants that have antibacterial function.
- Explain that a zone of inhibition is an area without bacterial growth on the petri dish.
- **Optional:** Create an educational comic strip to communicate information about bacterial meningitis **or** the antibacterial properties of garlic.

Standards Alignment

Washington State Essential Academic Learning Requirements (EALRs): Science
Science EALR 2: Inquiry <ul style="list-style-type: none">• 6-8 INQA—Question• 6-8 INQB—Investigate• 6-8 INQC—Investigate• 6-8 INQD—Investigate
Science EALR 3: Application <ul style="list-style-type: none">• 6-8 APPH
Next Generation Science Standards (NGSS)
Growth, Development, and Reproduction of Organisms <ul style="list-style-type: none">• MS-LS1-5

Common Core Standards: English Language Arts (ELA)

Reading Standard for Literacy in Science and Technical Subjects: Key Ideas & Details

- CCSS.ELA-Literacy.RST.6-8.1
- CCSS.ELA-Literacy.RST.6-8.3

Writing Standard for Literacy in Science and Technical Subjects: Text Types & Purposes

- CCSS.ELA-Literacy.WHST.6-8.2d
- CCSS.ELA-Literacy.WHST.6-8.2f

Language Standard 4c & 6: Vocabulary Acquisition & Use

- CCSS.ELA-Literacy.L.6.4c
- CCSS.ELA-Literacy.L.6.6

TEACHER PREPARATION

Materials

Teacher Preparation Materials

Most lab materials are provided in the *Sowing the Seeds of Neuroscience* classroom kit. The starred (*) items below are provided in your kit only if you requested them. The beakers provided in your kit are too small to make all of your agar at once. You can make several batches with the beakers provided, or you can use your own larger beakers to facilitate this process.

Item	Quantity
Garlic	1 head per class
Mortar and pestle	1
Tryptic soy agar	40 g
Water (distilled if available)	1000 ml
Hot plate*	1
Balance*	1
Beaker	1
Gloves*	1
Sterile small petri dishes	100
<i>M. luteus</i> culture from Carolina Biological	1
Microcentrifuge tubes	1 per group

Classroom Materials

Item	Quantity
Copies of <i>Botanical Superheroes Background Reading: Part One—Student Handout</i>	1 per student
Copies of <i>Botanical Superheroes Background Reading: Part Two—Student Handout</i>	1 per student
Copies of <i>Botanical Superheroes Lab Procedure—Student Handout</i>	1 per student
Copies of <i>Petri Dish Drawings & Observations—Student Handout</i>	1 or more per student, depending on how many days of observation
Copies of <i>Botanical Superheroes Results & Conclusions—Student Handout</i>	1 per student
Optional: Copies of <i>Botanical Superheroes Vocabulary Quiz—Student Handout</i>	1 per student
Student lab notebook	1 per student
Pen	1 per student
Classroom computer and projector	1
Optional: Colored pens or pencils	Assorted
Optional: Blank paper for comic strips	1 per pair

Laboratory Materials

Review the materials with your students. It will be helpful to show them each piece of lab equipment and mention how it will be used in this activity.

Most lab materials are provided in the *Sowing the Seeds of Neuroscience* classroom kit. The starred (*) items below are provided in your kit only if you requested them. There are enough materials in the classroom kits for ten groups to do this laboratory. Depending on class size, groups should be made of two to three students.

Item	Quantity
Garlic	1 head per school
Mortar and pestle	10
Essential oils (can use any from the “Scentscational” activity from the <i>Infusions & Decoctions</i> lesson plan. Clove oil and tea tree oil work especially well).	6 per school
Petri dishes pre-poured with Tryptic soy agar	2 per group
Aliquot of <i>M. luteus</i> culture in a microcentrifuge tube	1 per group
Sterile swabs	1 package per group
Filter paper discs	2 per group

Penicillin filter paper discs	1 package per school—ensure that at least 3 groups test penicillin
Plastic pipettes	2 per group
Permanent markers	1 per group
Piece of paper towel	1 per group
Forceps	1 per group
Metric ruler	1 per group

Safety Materials

Item	Quantity
Safety goggles*	1 per student
Gloves*	1 pair per student

*Safety materials are provided in the classroom kit only if you requested them.



Lab Safety

- Students must not eat or drink anything in the lab.
- When working with bacteria, students must always wear gloves and goggles. Students should wash their hands after completing the lab.
- In this lab, students will add plant extracts to a petri dish containing nutrient agar and a *Micrococcus luteus* (abbreviated as *M. luteus*) bacterial culture. We are using *M. luteus* in this test because this bacteria poses no danger to humans, is available from science supply companies, and grows well at room temperature.

Preparation

- Purchase fresh garlic.
- Early in the morning or the day before delivering this lab, you will need to prepare the agar petri dishes. Follow these procedures:
 - To make 100 petri dishes, combine 40 g Tryptic soy agar with 1000 ml water.
 - Mix the agar well.

- Using a hot plate or microwave, bring the agar/water combination **to a boil**. Stir well every few minutes while coming to a boil. **Note:** Agar mixtures are prone to boiling over, so please watch carefully.
- Remove the agar from the heat and allow to cool for three to five minutes.
 - **Note:** If you cool longer than five minutes, it will be hard to pour all of your petri dishes before the agar gels. If the agar gels before you have finished cooling, simply return to the microwave/hot plate to heat up again. You do not need to boil it this time, just warm it up enough to melt it.
- Pour a thin layer of agar into the petri dishes. Keep sterile petri dishes closed until you are ready to pour agar into them. Aim to have a similar height of agar in all dishes.
- Agar plates must cool for at least 45 minutes before students add bacteria.
- Aliquot 1 ml *M. luteus* stock culture into individual microcentrifuge tubes. Label these tubes “*M. luteus*” or “Bacteria”.
- Select a student to make garlic juice (or make it yourself). To do so, the student should be given a mortar and pestle and garlic (one or two cloves should be fine). The student can smash the garlic using a mortar and pestle until it makes a “juice.” The student can add a little water to make it more liquid if necessary. **Note:** Fresh juice is important! Prepackaged, bottled garlic, or garlic extracts do not work well, even if they still smell strongly of garlic.
- Plan what students will test on each plate. Each group will have two plates: one plate should be used to test an essential oil and the other should be used to test one of the items listed below. Within each class, if each group tests a different essential oil, you may be able to test all of the oils (although tea tree and clove are particularly effective—so you may choose to use only these). In addition to **testing an essential oil**, have each group test **one** of the following things:
 - **Penicillin:** This can be used to compare the effectiveness of the plant extract with an antibiotic known to work against this bacteria.
 - **Water Control:** This plate should be spread with bacteria as usual. However, water rather than a plant extract should be placed on the paper disc.
 - **Negative Control:** This plate should **not** be spread with bacteria. This will enable you to determine whether any ambient bacteria from your classroom is growing on the plates. If this plate looks like *M. luteus*, there are two explanations: 1) Maybe some *M. luteus* got onto this plate or 2) Maybe what you have growing in the plates isn’t *M. luteus* at all. More likely, you will have no bacteria, or a small growth of bacteria that looks different from *M. luteus*.
 - **Garlic juice extract.**

- Photocopy Student Handouts.
- Assign the *Botanical Superheroes Background Reading: Part One—Student Handout* to students as homework prior to starting this lesson.
- Plan your timing: It may work best to do this lab activity over three class periods, with some time in between for observations of the growing bacteria.
 - On Day One, deliver the *Engage* portion of the lesson, making the connection between bacteria and neurological disease such as meningitis, and guide students through a review of the background reading, learning goals, and vocabulary.
 - On Day Two, you will need about 20-30 minutes for student groups to set up their plates as described in the *Explore* portion of the lesson.
 - During the Incubation Period, additional classroom time is needed during the days that follow for students to check their growing bacteria and make drawings. Depending on the temperature of the classroom, it may take between 4-10 days for full bacterial growth.
 - A Third Day is needed for the class to share and discuss data and for students to complete the assessment tasks (*Explain, Elaborate, and Evaluate* portions of the lesson).

TEACHER PROCEDURE

Day One

Engage

1. Explain the purpose of the lesson and review Big Idea, Enduring Understanding, and Essential Question. Review the student background reading on the *Botanical Superheroes Background Reading: Part One—Student Handout*.
2. Using the classroom computer and projector, show students this poster from the Meningitis Trust (choose the “Student Awareness Poster”):

Student Awareness Poster

The Meningitis Trust, UK

<http://www.meningitis-trust.org/how-we-help/resources/>



3. Ask students to share their responses to the poster. What do they notice first? What do they wonder about?
4. Discuss what students already know about meningitis and what they want to know about meningitis. Create a K/W/L chart to record students' responses in the "K" and "W" columns, as shown below.

What I K now About Meningitis	What I W ant to Know About Meningitis	What I L earned About Meningitis & the Antibacterial Properties of Plants

5. Ask students: What do you think meningitis has to do with our investigation of plants that have neuroactive properties?
6. Distribute copies of *Botanical Superheroes Background Reading: Part Two—Student Handout*, one per student. Allow time in class for students to read the handout.

Day Two

Explore

7. Provide an overview of the lab investigation. Review safety information, emphasizing the importance of wearing goggles and washing hands after handling the bacteria.
8. Review **zone of inhibition** in the context of diffusion. Plant extracts will diffuse from the paper disk into the agar. The highest concentrations of the extract will be near the disk—as you move away from the disk, the concentration decreases. If you see a zone of inhibition on a petri dish, this means that some concentration of the extract prevented bacterial growth. In the case of penicillin with the small plates provided, the zone of inhibition may take up the whole plate!



- Using the classroom computer and projector, show students the “Bacteria Preparation” video from the Sowing the Seeds of Neuroscience website. The short video demonstrates the preferred technique for inoculating the petri dishes.

“Bacteria Preparation” Video (0:42 mins)

<http://www.neuroseeds.org/About-Neuroseeds/Lessons/superheroes>

- Distribute copies of the *Botanical Superheroes Lab Procedure—Student Handout*, one per student. Allow time for student groups to complete the lab investigation.
- Also distribute copies of *Botanical Superheroes Petri Dish Drawings & Observations—Student Handout*. Provide one or more copies per student, depending on how many days you anticipate students will be making observations of the petri dishes. Alternatively, you may have students make their sketches in their lab notebooks.
- Provide instructions on the location you will be using to incubate the petri dishes. A warm spot is ideal. Also provide instructions on your preferred clean-up procedures.

Incubation Period (over the next 4-10 days)

- Depending on the temperature of the classroom environment, it may take between 4-10 days for full bacterial growth. Growth can be considered “complete” when the water control plate is covered with bacteria. However, some plates may continue to grow even after the water control plate is covered with bacteria. You can choose to end the experiment at any point, depending on your availability of time.
- It is important for students to make observations and drawings of the plates at the beginning and end of the incubation period. If you have time available, it would be beneficial for students to take 10-20 minutes from a few class periods to make additional observations and drawings during the incubation period. A scoring rubric has been provided for this learning task.
- Once the experiment is complete, petri dishes should be soaked in a 10% bleach solution for 24 hours; they can then be thrown away in the garbage.

Day Three

Explain

16. Bring the class back together to discuss the results of their investigations. Draw a table to record class data (an example has been provided below). Then, ask each lab group to share the following:

- What two substances did your group test?
- Was your group's plant extract effective at preventing bacterial growth? How do you know?

Substance Tested	Antibacterial Properties?	Observations
Water Control		
Negative Control		
Garlic		
Penicillin		
Lavender Essential Oil		
Grapefruit Essential Oil		
Cedar Essential Oil		
Tea Tree Essential Oil		
Lemongrass Essential Oil		
Clove Essential Oil		

17. Review the class data. Ask the students if they think that any of the plants they tested have potential medicinal value.

Elaborate

18. As a class, return to the K/W/L chart you created at the beginning of the lesson. Ask for student volunteers to share their favorite "new things" and record their responses in the "L" column of the class chart: "What I learned about meningitis." In addition, challenge students to also add what they learned about the antibacterial properties of plants.

What I K now About Meningitis	What I W ant to Know About Meningitis	What I L earned About Meningitis & the Antibacterial Properties of Plants

19. Take some time to review the “K” column. Is there anything in this column that students now know to be incorrect? If so, amend the chart so that the statements are scientifically correct.
20. Also review the “W” column of the class chart. Is there anything that students wanted to know about meningitis that hasn’t yet been covered? If possible, take time to discuss these topics.
21. Ask students the same question that you asked at the beginning of the lesson: What do you think meningitis has to do with our investigation of plants that have neuroactive properties?

Evaluate

22. Distribute copies of the *Botanical Superheroes Results & Conclusions—Student Handout*, one per student. Allow time for students to independently complete the assessment questions. An answer key has been provided for this learning task.
23. In this lesson, we present the metaphor of garlic as a biological superhero. In this case, the super villain is the bacteria that causes meningitis. Share with students the CDC’s Case File on Meningitis Mutants that takes this superhero metaphor even further.



Case File: Meningitis Mutants

Centers for Disease Control and Prevention

<http://www.cdc.gov/bam/diseases/immune/db/meningitis.html>

Challenge students to work in pairs to develop an educational comic strip highlighting the superpowers of garlic or the super villain powers of the bacteria that cause meningitis.

The comic strip should either:

- a) Highlight the super powers of garlic by accomplishing one of the following:
- Educates the reader about what scientists currently know about garlic’s antibacterial properties.
 - Educates the reader about how garlic has been used throughout history to treat medical conditions.
 - Explains how plants with antibacterial properties may be able to reduce the incidence of bacteria-borne illnesses, like meningitis.
- b) Explain the super villain powers of the bacteria that cause meningitis by accomplishing one of the following:
- Explains how bacterial meningitis infects the body.
 - Educates the reader about the signs and symptoms of meningitis;
 - Explains the importance of meningitis vaccinations.
 - Explains that antibiotics are used to treat bacterial meningitis.



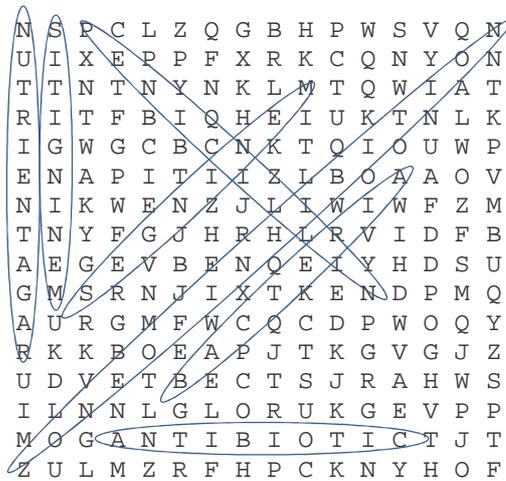
A scoring rubric has been provided for this learning task.

24. **Optional:** Assign a vocabulary quiz using the terms introduced on the Student Handouts. Hand out copies of *Botanical Superheroes Vocabulary Quiz—Student Handout* and administer it like a quiz with no peeking at lab notebooks or the Background Reading.

SCORING GUIDES

Answer Key for Vocabulary Quiz 7 possible points.

The *Botanical Superheroes Background Reading—Student Handout* can be used to correct students' definitions of the vocabulary terms. The location of the vocabulary terms in the word scramble is shown below:



Antibiotic, Bacteria, Meninges, Meningitis, Nutrient Agar, Penicillin, Zone Of Inhibition

Scoring Rubric for Drawings & Measurements of Petri Dishes

15 possible points.

Students are asked to draw the petri dishes on Day One and throughout the Incubation Period (based on teacher's preference). During each of these checks, students should draw a sketch of both of their petri dishes and make notes on their observations. In particular, students need to label their sketches with the date and the name of plant extract/control/antibiotic being tested. They also need to record the measurement of the zone of inhibition.

Dimension	Needs Work (0 Points)	Basic (1 Point)	Proficient (3 Points)	Advanced (5 Points)
Labels	No labels included.	Some items that need to be identified have labels. It is not always clear which label goes with which structure.	Almost all items that need to be identified have labels.	Every item that needs to be identified has a label.
Drawing	Overall, the quality of the drawings is poor.	Overall, the quality of the drawings is fair.	Overall, the quality of the drawings is good.	Overall, the quality of the drawings is excellent.
Observations and Measurements	Notes rarely taken or of little use.	Dated notes and measurements are taken occasionally, but accuracy of notes might be questionable.	Dated, clear, accurate notes and measurements are taken occasionally.	Clear, accurate, dated notes and measurements are taken regularly, each time that the petri dishes are checked.

Rubric created at Rubistar.4teachers.org

Answer Key for Results & Conclusions Student Handout

15 possible points.

Results:

Question	Proficient Answers
Was your plant extract effective at preventing bacterial growth? How do you know? (Hint: What does the zone of inhibition tell you?)	<p>Student states whether or not plant extract prevented bacterial growth. (1 point)</p> <p>Answer is provided in reference to the presence/absence of a zone of inhibition. (1 point)</p>
How did the plant extract you tested compare to extracts tested by your classmates? How did these compare to the penicillin test?	<p>Student provides a comparison of their plant extract to that tested by other student groups, stating if their extract was more or less effective than others. (1 point)</p> <p>Student provides a comparison of their plant extract to penicillin, stating if their extract was more or less effective at inhibiting the growth of bacteria. (1 point)</p>
Name at least two plants that have antibacterial properties.	Student correctly identifies at least two plants that were shown by the class to inhibit the growth of bacteria. (2 points)
Why did we ask your class to do a negative control and a water control? What did you learn from these?	<p>Student explains that a scientific investigation needs to have a control and a variable in order to elicit trends and patterns. (1 point)</p> <p>Student identifies at least one thing that they learned from the negative control and water control. (1 point)</p>

Conclusions:

Does the plant you tested have potential medicinal value? If so, what?	Student states if they think the plant they tested has potential medicinal value depending on its ability to inhibit the growth of bacteria. (1 point)
In a short paragraph, explain how botanical superheroes like garlic may prove helpful in preventing or treating bacteria-borne neurological illnesses like meningitis.	<p>Student provides a detailed conclusion clearly based on class data and related to previous research findings about garlic's ability to inhibit the growth of bacteria. (3 points)</p> <p>Student makes a clear connection between the antibacterial properties of plants and their potential pharmaceutical uses to prevent or treat bacteria-borne neurological illnesses. (3 points)</p>

Scoring Rubric for Super Hero/Super Villain Comic Strip

15 possible points.

Student pairs are challenged to produce an educational comic strip highlighting the superhero powers of garlic or the super villain powers of the bacteria that cause meningitis. The comic strip can educate about a variety of topics; you may allow students to pick their preferred topic or you may want to assign topics to different groups so that the class as a whole covers all of the possible topics.

The comic strip should either:

- a) Highlight the super powers of garlic by accomplishing one of the following:
 - Educates the reader about what scientists currently know about garlic's antibacterial properties.
 - Educates the reader about how garlic has been used throughout history to treat medical conditions.
 - Explains how plants with antibacterial properties may be able to reduce the incidence of bacteria-borne illnesses, like meningitis.

- b) Explain the super villain powers of the bacteria that cause meningitis by accomplishing one of the following:
 - Explains how bacterial meningitis infects the body.
 - Educates the reader about the signs and symptoms of meningitis.
 - Explains the importance of meningitis vaccinations.
 - Explains that antibiotics are used to treat bacterial meningitis.

Dimension	Needs Work (0 Points)	Basic (1 Point)	Proficient (3 Points)	Advanced (5 Points)
Educational Message	Students did not choose one of the available educational messages.	Students chose one of the available educational messages, but the comic strip does not clearly communicate this message.	Comic strip clearly communicates the students' chosen educational message	Comic strip clearly communicates the students' chosen educational message. Humor and creativity are used to communicate the message.

Scientific Concepts	Comic strip illustrates inaccurate understanding of scientific concepts. Less than half of the content is in the students' own words and/or is accurate.	Comic strip illustrates a limited understanding of scientific concepts. At least half of the content is in the students' own words and is accurate.	Comic strip illustrates an accurate understanding of most scientific concepts. Almost all content is in the students' own words and is accurate.	Comic strip illustrates an accurate and thorough understanding of scientific concepts. All content is in the students' own words and is accurate.
Clarity and Neatness	Comic strip is hard to read. It would be impossible for another person to read it without asking lots of questions.	Comic strip is hard to read with rough drawings and labels. It would be hard for another person to read it without asking lots of questions.	Comic strip is easy to read and most elements are clearly written, labeled, or drawn. Another person would be able to read it without asking questions.	Comic strip is easy to read and all elements are clearly written, labeled, or drawn that another person easily could read it. Comic strip is colorful, neat, and creative.

Rubric created with the help of Rubistar.4teachers.org

EXTENSIONS

- Show students several of the Voices of Meningitis videos. In particular, students may resonate with the stories of Tyler (the boy and mom sitting on floor) or Amy (the young woman sitting on floor). Discuss the impact that meningitis has on patients and their families. Why is it important to continue research into vaccines, diagnostics, and treatments for this disease?

Voices of Meningitis Videos (Spanish subtitles available)

<http://voicesofmeningitis.org/#>

- Challenge students to choose one of the careers listed in the *Career Connections* section of this lesson plan and to consider how a person in that career might study or use plants with antibacterial properties.

TEACHER BACKGROUND & RESOURCES

Resources

Complementary and Alternative Medicine Guide: Garlic

<http://www.umm.edu/altmed/articles/garlic-000245.htm#ixzz2M9JvM5dL>

Garlic and Cancer Prevention Fact Sheet

<http://www.cancer.gov/cancertopics/factsheet/Prevention/garlic-and-cancer-prevention>

Bacterial Meningitis

<http://www.cdc.gov/meningitis/bacterial.html>

Neuroscience for Kids: Bacterial Meningitis

<http://faculty.washington.edu/chudler/menin.html>

Monty the Duck Interactive: Learning about Meningitis (For younger students)

The Meningitis Trust, UK

<http://www.meningitis-learning.org/MontyAndFriends/Default.aspx>

The Zone: Learning about Meningitis (For older students)

The Meningitis Trust, UK

<http://www.meningitis-learning.org/The-Zone/Default.aspx>

Signs & Symptoms of Meningitis in Children and Teens

<http://www.meningitis-trust.org/meningitis-info/signs-and-symptoms/children-and-teenagers/>

Career Connections

Microbiologist: A microbiologist is a scientist who studies microscopic organisms, such as bacteria and fungi; they also study viruses. A microbiologist may work in the fields of medicine, veterinary medicine, or pharmaceuticals studying disease-causing agents. They also may work in the fields of food safety or environmental science.

Nurse: A nurse may work in doctor's offices, hospitals, or nursing homes. They also may work in schools, correctional facilities, and military facilities. They perform a variety of medical tasks, including taking vital signs, giving injections, drawing blood, and helping with personal hygiene. School nurses may review students' vaccination records to ensure they meet the district's requirements. Two types of nurses include registered nurse (RN) and licensed practical nurse (LPN). Each must obtain a degree in nursing, work in a clinical setting, and pass a licensing examination.

Pharmacologist: A biomedical scientist that studies the interactions between drugs and cells, tissues, organs, or entire organisms. Pharmacologists are primarily concerned with research.

Vaccine Scientist: A vaccine scientist conducts research to develop new vaccines to immunize people or animals against a bacteria or virus. These scientists typically study biology, immunology, or zoology in school. They work in research and development (R&D) laboratories, usually in university, government, or corporate settings.

Illustrations and Photograph Credits

Photograph of Garlic Head and Cloves. Courtesy of Wikimedia Commons, Donovan Gonan. 24 April 2005.

Photograph of *Allium sativum* Plant. Courtesy of Wikimedia Commons, H. Zell. 5 July 2009.

Illustrations of Meningitis Mutants. Courtesy of the CDC, Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion.

Photograph of Infant Receiving an Immunization. Courtesy of the CDC, Judy Schmidt. Photo credit: James Gathany, 2006.

Photographs of Lab Procedures. Courtesy of Eric Chudler and Kristi Straus, University of Washington. 2013.

Bibliographic Credits

Centers for Disease Control and Prevention. "Bacterial Meningitis." 2012. Web. 7 February 2013. <<http://www.cdc.gov/meningitis/bacterial.html>>.

"Garlic and Cancer Prevention." National Cancer Institute, n.d. Web. 7 February 2013. <<http://www.cancer.gov/cancertopics/factsheet/prevention/garlic-and-cancer-prevention>>.

"Garlic." University of Maryland Medical System. (May 7, 2013). Web. 7 February 2013. <<http://www.umm.edu/altmed/articles/garlic-000245.htm#ixzz2M9JvM5dL>>.

Parker-Pope, T. "Unlocking the Benefits of Garlic." *The New York Times*. (October 15, 2007). Web. 7 February 2013. <<http://well.blogs.nytimes.com/2007/10/15/unlocking-the-benefits-of-garlic/?em&ex=1196485200&en=adbf87299dd99e92&ei=5087%0A>>.

Rivlin, R.S. "Historical Perspective on the Use of Garlic." *The Journal of Nutrition* 131:3 (2001): 951S-954S. Web. 7 February 2013. <<http://jn.nutrition.org/content/131/3/951S.full>>.

BOTANICAL SUPERHEROES BACKGROUND READING: PART ONE STUDENT HANDOUT

Name: _____ Date: _____ Period: _____

It's a Bird, It's a Plane, It's Super Garlic!

If garlic was a superhero, it would pack quite a punch. Wearing a green cape and tights, Super Garlic would fight the good fight. Walloping cancer! Boosting the immune system! Giving heart disease the boot! Saving damaged DNA! Fighting the invasion of bacterial super villains!



Have you heard that garlic is supposed to be good for you? That you should eat garlic when you feel like you are getting sick? Since ancient times, people around the world have been using garlic for its health benefits. Garlic cloves were found in the ancient Egyptian tomb of King Tut. In the first Olympic Games in ancient Greece, athletes ate raw garlic before their competitions. It was fed to ancient Greek and Roman soldiers before battle and was taken to sea along with their sailors. Garlic is quite the botanical superhero!

Neurological benefits:

- Used by the ancient Romans to treat convulsions (seizures).
- Used in ancient China and Japan to treat depression.

Other health benefits:

- The ancient Greeks used garlic to protect the skin from poisons.
- Used by the ancient Romans to treat digestion problems, animal bites, arthritis, and parasites.
- Used in ancient China and Japan to treat digestion and respiration problems, male infertility, and to boost energy.
- Used in ancient India to treat heart disease, arthritis, fatigue, parasites, digestive problems, and leprosy.
- In the Middle Ages, garlic was used as a treatment for the plague.

Today, scientists are studying garlic's ability to: prevent and fight cancer, lower cholesterol, lower blood pressure, boost the immune system, and treat **meningitis**.

As you learned in the *Chromatography* lab, plant extracts are made up of complex combinations of chemical compounds; it can be difficult for scientists to identify which chemicals are causing a particular health benefit. Scientists know that garlic contains the following chemicals that may have health benefits: sulfur, arginine, oligosaccharides, flavonoids, and selenium. But scientists aren't exactly sure how garlic helps protect against certain kinds of cancer. One idea is that garlic has natural antibacterial properties. Another is that garlic can help increase the body's natural supply of hydrogen sulfide, a chemical that helps repair damaged cells, increase blood flow, and protect the heart.

BOTANICAL SUPERHEROES BACKGROUND READING: PART TWO STUDENT HANDOUT

Name: _____ Date: _____ Period: _____

Bacteria: The Good, the Bad, and the Ugly

In this lab investigation, you are going to explore whether garlic might be good for you because it is bad for **bacteria**. Bacteria are single celled organisms that lack a nucleus. Bacteria are all around us and can be both beneficial and harmful to human beings. Our intestines are full of good bacteria that help us to digest our food and absorb nutrients. Cheese, yogurt, chocolate, wine, sourdough bread, beer, kimchee, and sauerkraut are just some of the foods created by bacterial fermentation.



Bacteria can also be bad for us, causing many diseases including some neurological diseases. Bacterial **meningitis** occurs when a bacterial infection causes the protective membranes surrounding the brain and spinal cord (the **meninges**) to become inflamed. The first symptoms of bacterial meningitis are suddenly getting some combination of a severe headache, stiff and sore neck, fever, rash, vomiting, diarrhea, and sensitivity to bright lights. It is a serious illness that can cause hearing loss, brain damage, amputations, or learning disabilities. It can even be fatal.

Bacterial meningitis is just one type of meningitis. It can also be caused from a virus, fungus, or parasite. Some people get meningitis as a result of cancer or brain surgery.

There are several types of bacteria that can cause meningitis. Childhood immunizations help protect against three of these types of bacteria: *Neisseria meningitidis* (meningococcus), *Streptococcus pneumoniae* (pneumococcus), and *Haemophilus influenzae* type b (Hib). Because bacterial meningitis is caused by a bacterial infection, it can be treated with **antibiotics**.

Bacteria-Fighting Plants

Can botanical superheroes like garlic help prevent or treat bacteria-borne illnesses like meningitis? In this lab, you will investigate the antibacterial properties of certain plants. Perhaps one of these botanical superheroes will one day be used in the fight against bacteria-borne neurological illnesses.

This activity shows you one way to determine whether certain plant extracts and antibiotics can prevent bacterial growth. To do this, you will add your plant extract to a petri dish containing **nutrient agar** and a *Micrococcus luteus* (abbreviated as *M. luteus*) bacterial culture. We are using *M. luteus* in this test because this bacteria poses no danger to humans, is available from science supply companies, and

grows well at room temperature. We will compare how well plant extracts and **penicillin** prevent the growth of the *M. luteus* bacteria.

Botanical Superheroes Vocabulary List

Antibiotic: A medicine that is used to fight a bacterial infection. **Penicillin** is a commonly used antibiotic.

Bacteria: Single celled organism that lack a nucleus. Also called prokaryotes.

Meningitis: A serious neurological illness that results in inflammation of the **meninges**. Meningitis is usually caused by bacteria or a virus.

Meninges: The protective membranes surrounding the brain and spinal cord.

Nutrient agar: Agar is a substance used in science labs to grow bacteria in a petri dish. Agar looks like jelly and is made from red algae that grows in the ocean. Nutrient agar has nutrients added to it to help the bacteria grow. The nutrient agar used in this lab is Tryptic soy agar which gets its nutrients from soybeans and milk protein.

Penicillin: A group of **antibiotics** that are commonly used to treat bacterial infections, such as ear infections.

Zone of Inhibition: The clear area (with no bacteria) on your petri dish. Because you covered the petri dish with bacteria, this clear area demonstrates the absence (or inhibition) of bacteria due to the plant extract or penicillin.

BOTANICAL SUPERHEROES LAB PROCEDURE STUDENT HANDOUT

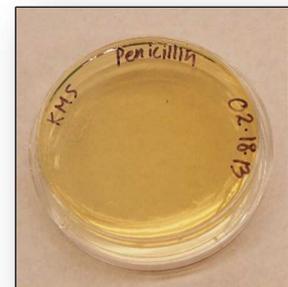
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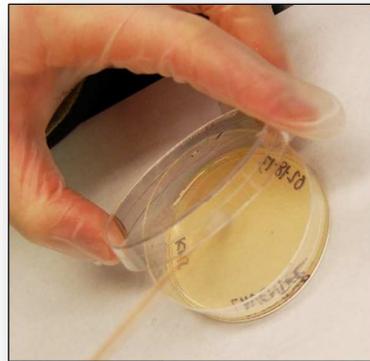
Your group will need the following laboratory materials:

Goggles and gloves	1 per student
Petri dishes pre-poured with Tryptic soy agar	2
Aliquot of <i>M. luteus</i> culture in a microcentrifuge tube	1
Sterile swabs	1 package
Filter paper discs	2
Plastic pipettes	2
Permanent marker	1
Piece of paper towel	1
Forceps	1
Metric ruler	1
You will also need access to: mortar and pestle, essential oils, garlic, and penicillin filter paper discs	As needed

Lab Procedure

- Put on your goggles and gloves.
- Label the bottom of your petri dishes—not the lid. Write small and try to write along the edge of the plate rather than in the middle—so that you'll be able to see what your bacteria look like without the text getting in the way. Use a permanent marker to label your petri dish with:
 - Your initials or team #.
 - The date.
 - What you are testing on this petri dish (such as "Penicillin" or "Garlic") or write "Negative Control" or "Water Control" if you are testing these.
- Add your bacteria to both petri dishes. **If you have a negative control plate, do not add bacteria to this plate.**
 - Using a sterile swab, dip into the microcentrifuge tube of bacteria. Make sure that the swab is wet.
 - Rub this swab all over your petri dish. One way to make sure that the entire surface is covered with bacteria is to swab the bacteria onto your petri dish using a zigzag motion. Then rotate the petri dish a quarter turn and swab it again in a zigzag motion. Rotate the petri dish a quarter turn and swab it in a zigzag motion two more times.





4. Using forceps, take a filter paper disk and saturate it (get it totally wet) with your plant extract.
 - a. If your plant extract is an **essential oil**, place your filter paper disk on a paper towel. Shake the essential oil bottle over the filter paper disk so that the filter paper becomes saturated with the oil.
 - b. If your plant extract is in a **beaker** or a **mortar and pestle**, use the forceps to hold your filter paper disk and dip it into the plant extract.
 - c. If you are using **filter paper in your water control**, dip the filter paper disk into water.
 - d. If you are using a **pre-soaked antibiotic disk**, simply use forceps to pick it up.



5. Place your filter paper disk into the middle of your bacterial petri dish. Be sure that the right disk goes onto the right petri dish! Cover the petri dish.
6. Wipe off your forceps with a paper towel.
7. Repeat Steps # 3-7 on your second petri dish.

- Place your petri dishes **upside down** (so the writing is on the top) in the location your teacher tells you. Bacteria grow faster if it is warm, so a warm spot in your classroom is ideal.



- Follow your teacher's instructions on how to clean up your lab station and put away lab equipment.

- Take off your gloves and throw them away. Wash your hands with soap and warm water.

- Draw your petri dishes on the *Petri Dish Drawings & Observations—Student Handout* or in your lab notebook. Use labels to clearly show what extracts and controls you tested. Date your drawing.

Incubation Period:

A few days after you've started your bacterial experiment, you will need to check and see how the bacteria are growing.

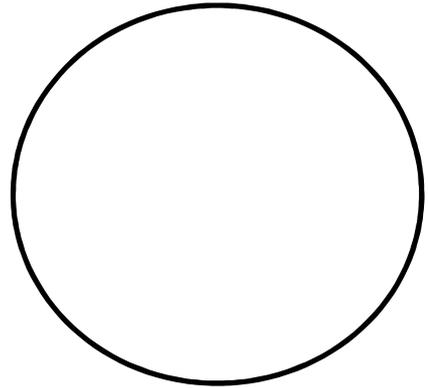
- Draw your petri dishes on the *Petri Dish Drawings & Observations—Student Handout* or in your lab notebook. Label your petri dishes to show the location, color, and size of any bacterial colonies on the petri dishes. Make sure it is clear what extracts and controls were tested! Date your drawing.
- Using a centimeter ruler, measure the **zone of inhibition**. Remember that you swabbed your bacteria evenly across the whole petri dish. If your plate has an area with no growth in the middle around your filter paper disk, this is a zone of inhibition. Record this measurement in your lab notebook.

**PETRI DISH DRAWINGS & OBSERVATIONS
STUDENT HANDOUT**

Name: _____ Date: _____ Period: _____

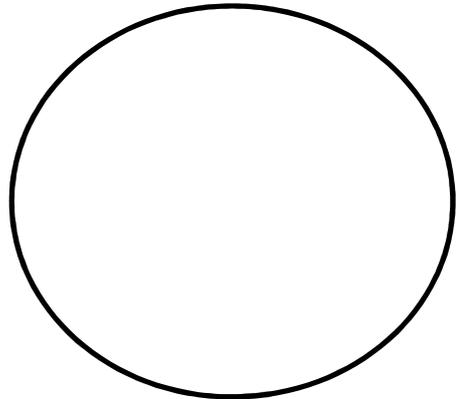
Day _____

Observations:



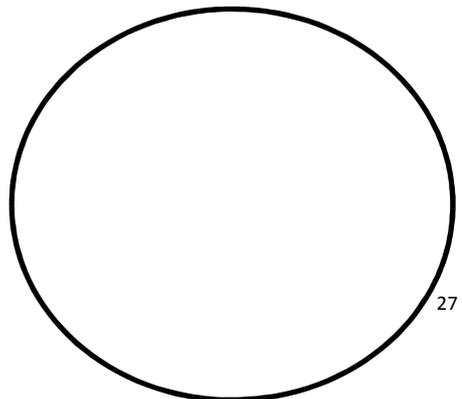
Day _____

Observations:



Day _____

Observations:



**BOTANICAL SUPERHEROES VOCABULARY QUIZ
STUDENT HANDOUT**

Name: _____ Date: _____ Period: _____

Directions: Find these vocabulary words in the word scramble. Then, in your own words, write a definition for each word.

ANTIBIOTIC
BACTERIA
MENINGES

MENINGITIS
NUTRIENTAGAR
PENICILLIN

ZONEOFINHIBITION

N S P C L Z Q G B H P W S V Q N
U I X E P P F X R K C Q N Y O N
T T N T N Y N K L M T Q W I A T
R I T F B I Q H E I U K T N L K
I G W G C B C N K T Q I O U W P
E N A P I T I I Z L B O A A O V
N I K W E N Z J L I W I W F Z M
T N Y F G J H R H L R V I D F B
A E G E V B E N Q E I Y H D S U
G M S R N J I X T K E N D P M Q
A U R G M F W C Q C D P W O Q Y
R K K B O E A P J T K G V G J Z
U D V E T B E C T S J R A H W S
I L N N L G L O R U K G E V P P
M O G A N T I B I O T I C T J T
Z U L M Z R F H P C K N Y H O F

Antibiotic:

Bacteria:

Meninges:

Meningitis:

Nutrient Agar:

Penicillin:

Zone of Inhibition: